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Project Status Report for: May 2001

Project Title: Ultra Low NOx Integrated System for Coal-Fired Power Plants

Project Number: 91890460 **Project Manager:** John Marion

Customer Name: U.S. DOE / Performance Projects **Project Leader:** Charles Maney

GOALS AND OBJECTIVES:

Develop low cost, retrofit NO_x control technologies to address current and anticipated, near term emissions control legislation for existing coal fired utility boilers. Specific goals include:

- Achieve < 0.15 lb/MMBtu NO_x for eastern bituminous coals
- Achieve < 0.10 lb/MMBtu NO_x for western sub-bituminous or lignitic coals
- Achieve economics at least 25% less than SCR-only technology
- Validate NOx control technology through large (15 MWt) pilot scale demonstration
- Evaluate the engineering feasibility and economics for representative plant cases
- Provide input to develop commercial guidelines for specified equipment
- Provide input to develop a commercialization plan for the resultant technologies

WORK PLANNED FROM PREVIOUS REPORT:

Task 2.4 – Advanced Control System Design

- Begin analysis of the flame scanner data.

Task 3.3 – Combustion Testing and Cleanup

- Begin cleanup from the second combustion test period in the BSF.

Task 3.5 – Data Reduction and Analysis

- Begin data reduction and analysis from second combustion test period.

Task 8 – Project Management

- Come to closure on the modified statement of work provided to DOE in Feb. 2001.

ACCOMPLISHMENTS FOR REPORTING PERIOD:

Task 2.4 – Advanced Control System Design

- *Begin analysis of the flame scanner data.*

Two traditional "off-on" flame scanners were installed in the main burner zone of the furnace. Unlike a standard installation, these sensors were located perpendicular to the flame axis. Both ultra-violet and visible light scanners were used to monitor the flame front during the test matrix including variation to the local and global stoichiometry. Scanner outputs were recorded to determine whether detector signal can be correlated to furnace condition for potential control and optimization.

Analysis of the flame scanner data is currently underway. Preliminary results indicate good signal levels were obtained throughout the test week as added care was taken to prevent ash buildup in the sight pipes as occurred during the first test period.

Task 3.3 – Combustion Testing and Cleanup

- *Begin cleanup from the second combustion test period in the BSF*.

Cleanup from the second combustion test period in the BSF has been largely completed. All scrubber waste has been disposed of and the fly ash has been cleaned from the large heat exchanger and associated ductwork. Cleanup of the Pulverizer Development Facility, used for manufacture of the test pulverized coal, has also been completed. Remaining cleanup items include disposal of the hopper ash and the surplus coal, as well as required general facility decommissioning and equipment storage, among others.

Task 3.5 – Data Reduction and Analysis

- *Begin data reduction and analysis from second combustion test period*.

The second combustion test period in the BSF was executed 4-30-01 through 5-5-01. During this testing two coals were fired in the BSF, a subbituminous coal from the Powder River Basin (Cordero Rojo Complex Coal, Kennecott Energy) and a high volatile bituminous coal from Southern Indiana. The as-fired (after pulverization) coal compositions are shown in Table 1, along with that of the medium volatile bituminous coal fired in the first week of BSF testing.

Approximately 80 test were run on the subbituminous coal and 35 on the high volatile bituminous coal. At each test condition, approximately gaseous emissions data including O2, CO, CO2, SO2 and NOx were collected along with high volume fly ash samples, which were recorded in all but a few select cases. During the second combustion test week the following variables were examined:

1. MBZ Stoichiometry
2. Staged Residence Time
3. Near Field Stoichiometry
   a. Transport air to fuel ratio
   b. Fuel air flow
   c. Subcompartmentalization
4. Transport Air & Fuel Flow Balancing
   a. Coal flow balancing
   b. Vertical coal bias (top coal%)
5. SOFA Elevation (1 vs. 2)

6. SOFA Velocity
7. Boiler Load
8. Coal Fineness (sub-bit coal)
9. Excess Air (USOFA flow variation)
10. Bottom End Air
    a. Quantity
    b. Location
11. Coal Ballistics
    a. Low-set / compressed WB
    b. Coal yaw / tilt

Table 1. BSF Test Coal Analyses, as Fired.

	Test Week 1 Pulverized Med Vol Bit	Test Week 2 Pulverized High Vol Bit	Test Week 2 Pulverized Cordero Rojo Sub Bit
Proximate			
VM	22.5%	37.7%	35.6%
FC	63.1%	51.4%	39.6%
FC/VM	2.8	1.4	1.1
VM, DAF	26.3%	42.6%	47.3%
Ultimate			
Moisture	0.9%	4.3%	18.9%
Hydrogen	4.0%	4.9%	3.7%
Carbon	74.7%	71.6%	56.4%
Sulfur	1.4%	2.5%	0.4%
Nitrogen	1.3%	1.5%	0.9%
Oxygen	4.2%	7.9%	13.8%
Ash	13.6%	7.2%	5.9%
Total	100.0%	100.0%	100.0%
HHV, BTU/lb	13,109	13,088	9,890
O/N	3.2	5.3	15.3
lb N/MMBTU	0.99	1.15	0.91
lb S/MMBTU	1.04	1.91	0.40
lb Ash/MMBTU	10.3	5.5	6.0

A summary of the NOx emissions from the 3 coals fired in the BSF is shown in Figure 1, while the carbon in the fly ash is shown in Figure 2. For each coal, a post-NSPS baseline (re. CCOFA only), TFS 2000™, and minimum NOx test condition are reported. Note that for the mvb and hvb coals, all three test conditions were run at a dynamic classifier grind of 85% -200 mesh. Hence, the test baseline numbers may not be representative of the actual baseline NOx and carbon in ash values that might be seen in the field. See Table 2 for the test conditions for each coal.

As illustrated in Figure 1, a decrease in the NOx emissions is seen as a function of coal rank and firing system configuration. A reduction of 65-75% over the baseline number was achieved with a TFS 2000™ firing system at the optimum main burner stoichiometry. Additional NOx reduction was achieved for each of the coals through optimized combinations of the test variables listed above.

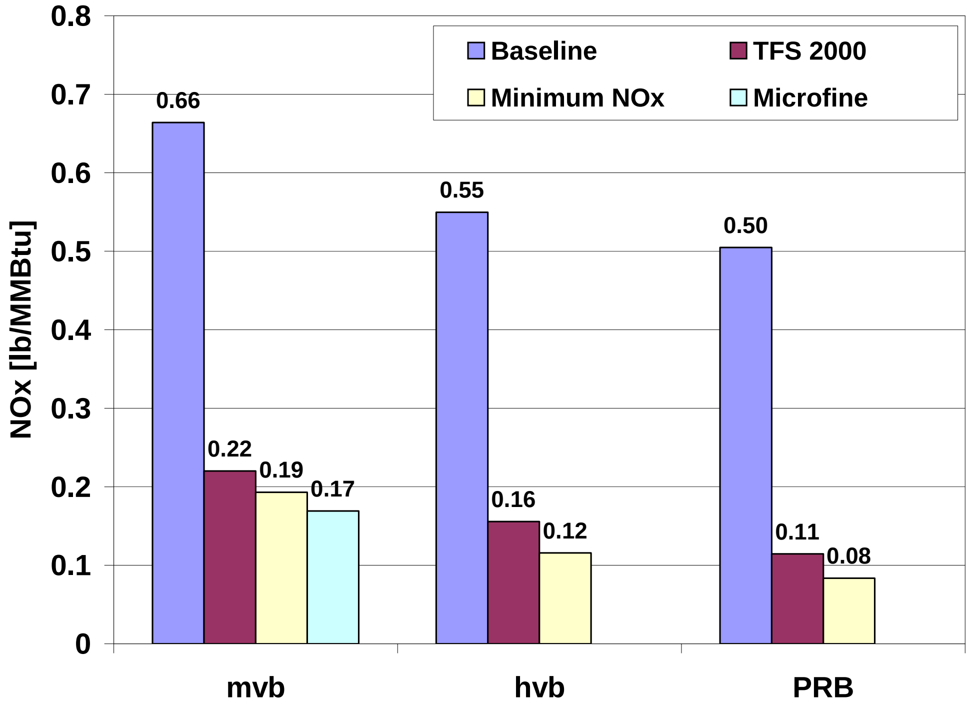

Figure 1. NOx emissions from BSF combustion testing.

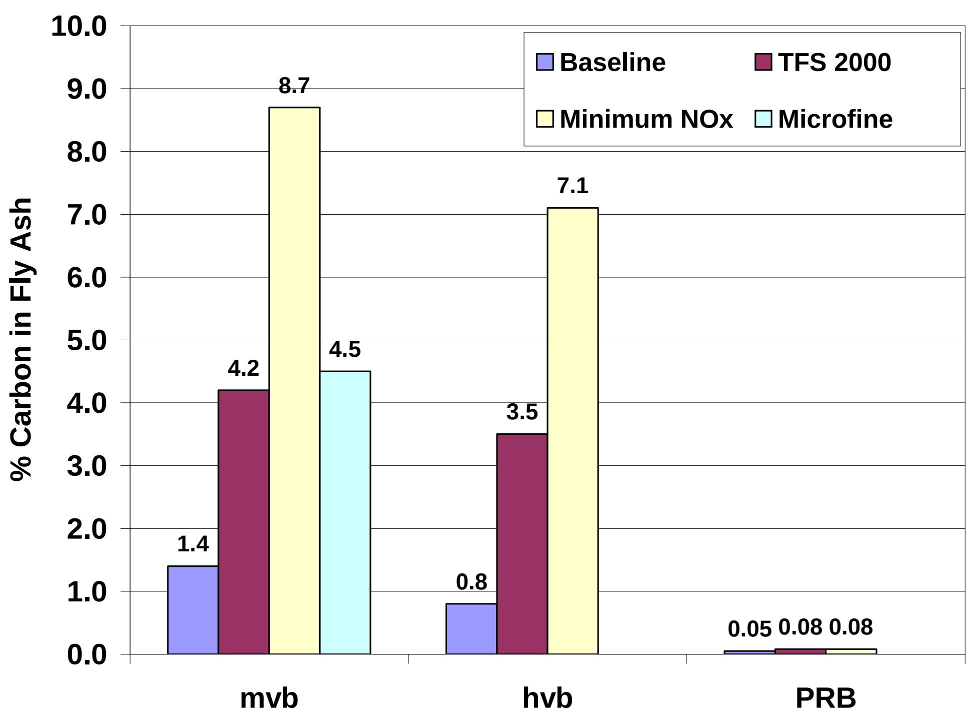

Figure 2. Carbon in fly ash results from BSF combustion testing.

Table 2. Test conditions for cases shown in Figures 1-2.

	Coal	Firing Rate [MMBtu/hr]	Grind [% -200 mesh]
Baseline	mvb	47	85
TFS 2000	mvb	47	85
Minimum NOx	mvb	47	85
Microfine	mvb	57	99.9
Baseline	hvb	47	85
TFS 2000	hvb	47	85
Minimum NOx	hvb	47	85
Baseline	PRB	47	70
TFS 2000	PRB	47	70
Minimum NOx	PRB	47	70

However, as illustrated in Figure 2, the carbon in the fly ash increased due to the firing system modifications made to decrease NOx emissions for the high and medium volatile bituminous coals. As expected, the Cordero Rojo PRB coal showed little carbon in the fly ash under any test condition, an additional benefit of firing such a coal. As noted above, the increase in carbon in ash for the bituminous coals versus firing system configuration is exaggerated as the baseline condition was run with high, dynamic classifier type coal fineness.

Results are also shown in Figures 1-2 for a microfine grind of the mvb coal. The additional coal particle size reduction allowed the carbon in ash level to be decreased to the TFS 2000™ level with the added benefit of additional NOx reduction. The smaller particle sizes burn more rapidly, releasing more of the fuel bound nitrogen in the reducing zone of the furnace which results in lower NOx and carbon in fly ash levels.

The results in the BSF illustrate the impact of coal type on the measured NOx emissions. Due to their higher volatile contents and char reactivity, the lower rank fuels can achieve lower NOx levels. More of the fuel bound nitrogen of the highly reactive coals is released in the substoichiometric region of the furnace which can be subsequently reduced to N_2. The volatile matter decreases with increasing coal rank, hence the higher-ranked fuels are not as amenable to fuel staged NOx reduction processes.

It should be noted that absolute NOx and carbon in ash emissions levels are also a function of the boiler design, including furnace height, furnace cross sectional area, firing zone heat release rates, etc. The Boiler Simulation Facility is a large pilot-scale test facility that was designed to span the available range of time temperature histories of commercial utility boilers. As such, the design and typical operating conditions of the BSF result in NOx and carbon in ash levels that are typically lower than which can be obtained in the majority of commercial utility boilers. As such, absolute results in the BSF are transferable only to utility boilers of similar overall furnace time-temperature history design characteristics. However, relative results of the BSF are broadly applicable and illustrate the effectiveness of firing system modification, including those achieved with the commercial TFS 2000™ system in lowering NOx emissions and suggest that additional NOx reduction over the commercially available firing system is possible.

Task 8 – Project Management

- *Come to closure on the modified statement of work provided to DOE in Feb. 2001*.

Answers to questions relating to the requested modified statement of work for the project were provided to our new DOE Contracting Officer's Representative (COR), Mr. Bruce Lani in May. Currently the proposed modifications to the statement of work are being reviewed by DOE. As the approval process is still underway.

- *IJPGC 01 paper*.

A paper entitled "Ultra-Low NO_X Integrated System for Coal Fired Power Plants" was presented on this project at the International Joint Power Generation Conference in New Orleans, LA (June 4-7, 2001). Results from this program, including the graphics shown above were included in the oral presentation.

WORK PLANNED FOR NEXT REPORTING PERIOD:

Task 2.4 – Advanced Control System Design

- Obtain preliminary results of the flame scanner data.

Task 3.5 – Data Reduction and Analysis

- Continue data reduction and analysis from second combustion test period.

Task 5 – Engineering Systems Analysis & Economics

- Begin final economic comparison of the selected ultra-low NOx emission systems.

Task 6 – Advisory Panel

- Schedule the next meeting of the Utility Advisory Panel.

Task 8 – Project Management

- Continue to attempt to come to closure on the modified statement of work provided to DOE in Feb. 2001.
- Hold internal meeting to review data from the second combustion test period.
- Begin discussions with business unit on commercialization plan.